7th International Conference on Water Resources and Arid Environments (ICWRAE 7): 461-464
4-6 December 2016, Riyadh, Saudi Arabia

Preferred Practices Techniques to Treat Greywater in Arab Countries for an Ablution Water Treatment Unit

[1,2]B. Halwani, [1]J. Halwani and [2]B. Ouddane

[1]Lebanese University, Water & Environment Science Laboratory, Public Health Faculty, Tripoli, Lebanon
[2]Lille 1 University, LASIR Laboratory, UMR CNRS 8516, 59655 Villeneuve d'Ascq Cedex, France

Abstract: Due to climate change and excessive use of freshwater resource, countries are searching for new techniques to reuse and recycle wastewater. The majority of Muslim countries are suffering from lack of water resources, many of them are using desalination of sea water techniques for their daily needs. Abulation water belongs to the category of greywater that is taking increasing attention. It constitutes 61% of the total wastewater and is less polluted then blackwater. More than 20 techniques were made and most of them were studied deeply, however in order to choose one technique we should take into consideration efficiency and economical aspect. In this article, we identified and compared most of techniques used for treating greywater. As a conclusion, slanted soil, constructed wetlands and biochar had the best elimination percentages in filtration, treatment systems and medias used in these systems respectively.

Key words: Abulation · Greywater · Techniques · Treatments

INTRODUCTION

Water is the most essential element for survival. It is known to be the vital vain of economy and social development of countries. The issue of water scarcity is influencing more and more the status of countries; with low and variable rainfall, high rates of evaporation and frequent droughts coupled with rapid population growth, all these contribute to low water resource reliability and availability. These entire problems are threatening the development of Arab countries; according to a study done by the UNDP [1], Arab countries cover 10 % of the world's area but receive only 2.1 % of its annual precipitation. Most Arab countries rely on groundwater to meet their demands, which resulted in the intrusion of sea water; therefore countries are forced to search for another source to alleviate stress from freshwater resources. All attention shifted then to nonconventional water resources that group desalinated water, treated wastewater, irrigation drainage water and water harvesting. Domestic wastewater can be divided into two major groups: Greywater and Blackwater. Greywater is less polluted because it is generated from kitchen sinks, washing machines, dishwashers, hand-washing basins and showers. According to the WHO study [2] greywater constitutes 50 to 60% of the domestic wastewater and this amount can be easily managed and treated for a reuse purpose. This "durable" source can be then used for toilet flushing, irrigation of lawns on college campuses, athletic fields, cemeteries, parks and golf courses, domestic garden, washing of vehicles and windows, fire protection, concrete production, infiltrate GW into the ground and uses in fountains and waterfalls [3].

With this rising new water source, many treatment techniques were being studied to achieve recycled water criteria's. Five filtration techniques were deeply studied (Slow sand filtration, Rapid sand filtration, Roughing filtration, Slanted soil and Biosand techniques), more than 20 techniques were used for treatment like Rotating Biological contactor, Sequencing bath reactor, Upflow anaerobic sludge blanket and many more and thirteen media were used (Silica, greensand, biochar, gravel, fine gravel, anthracite, activated carbon, lava rocks, fabric, ceramic filter, clay filter, diatomaceous and bark).

Within this huge evolution we have to take into consideration the approach of efficiency and economy. Because the economic state of Arab countries is decreasing, we have to search for the best way that can be affordable for most countries and be functional for different conditions. Techniques like slow sand filtration

Corresponding Author: J. Halwani, Lebanese University, Water & Environment Science Laboratory, Tripoli, Lebanon.

or rapid sand filtration can seem to be efficient but have a major disadvantage of being depend of space and can't be adapted for all conditions.

In this article we will list some of the most used techniques and review some case study from all over the world that treated greywater for a reuse purpose as an Ablution Water Treatment Unit.

Methods of Treatment: Based on biological, physical and chemical parameters, some techniques were more efficient than others. After comparing more than 30 techniques only few stood up the quality and profitability ratio: biosand, slanted soil, rapid sand filtration, activated carbon media, biochar media, constructed wetlands and moving bed bioreactor.

Biosand: The Biosand filter (BSF) is a system adapted from the slow sand filters. It's a combination of biological and physical processes that take place in a sand column covered with a biofilm. This technology is being applied in the developing countries is either constructed with concrete or plastic filled with gravel, followed by coarse sand and then fine graded quartz sand [4]. Different studies treated different pollutants parameters, Abudi, & coll [5] for example measured COD and BOD and obtained respectively 76% and 83% of elimination. Duke & coll [4] founded 62% of COD and 70% of TOC removal; they also treated the TSS, turbidity, TDS and *E. coli* and obtained respectively 75%, 96%, 54.75% and 99% removal. Lakshmi & Col. [6] shifted the parameters to englobe heavy metals with iron and manganese, bacteria viruses and protozoa to have an elimination percentage of 64%, 5%, 98.5%, 90% and 99.9% respectively.

Slanted Soil: This promising treatment system consists of several chambers containing soil that can be stacked vertically, this way it will take smaller place. Itayama [7] & Kondo [8] studied the kanuma soil in Japan, using alumina and hydrated silica. Both studies concluded that this system could remove organic pollutants, total nitrogen, total phosphorus and suspended solids. Kondo [8] reported some complication throw water volume and temperature. Ushijima, [9] and Itayama [7] reported 90.3% for COD, 85.75% for BOD, 78.37% for Tot-N, 85.1% for Tot-P and 78% for TSS.

Rapid Sand Filtration (RSF): The RSF is a large sand grains filter supported by gravel and capture particles throughout the bed. The advantage of rapid sand filters, that it treats a broad range of water, effectively removes colors and dissolved oxygen, requires smaller land and lower labor cost; it is a simple and low cost technology. It is moderately effective on guinea-worm, iron, manganese and turbidity; a little effective on bacteria, odor, taste and organic matter (OM). As the SSF, the RSF also have the clogging problem, also, it requires chemicals addition and a high level of operator skill. Yousaf [10] and Van Haute [11] both studied the COD with 25% and 70.4% respectively; also Yousaf [10] studied the BOD and had a 14%. The COD, Tot-N, Tot-P, TSS and TOC had respectively, 2.7%, 59.8%, 92.7%, 93.4% and 20%. Van Haute [11] and Deboch, [12] studied the turbidity removal of RSF and had 98.5% and 98.10% respectively.

Activated Carbon Media: The activated carbon is a common media used for water treatment due to its excellent adsorption capacity. This medium showed very interesting percentages of pollutants removal with 93.18%, 97.88%, 92.8%, 84.7%, 98.29%, 66%, 39.94% and 61% for COD, BOD, Tot-N, Tot-P, TSS, Turbidity TDS and total coliform respectively [13-14].

Biochar: The Biochar was getting the attention for the mutual similarity with activated carbon. This class of materials, that incorporate both charcoal and biocarbon is produced from different organic materials similar to the activated carbon, but without the activation. It is used generally soil improvement, waste management, climate change mitigation, energy production and of course pollutant removal [15]. Biochar offer same and sometimes better results than the activated carbon: 96% COD, 97% BOD, 94.47% Tot-N, 87.32% Tot-P, 99% TSS, 99% turbidity, 97% TOC and 96% *E. coli* removal [14, 16-19].

Constructed Wetlands: Constructed wetlands are used in small communities for its cheap and efficient water treatment. The concept of constructed wetlands is to use the natural processes involving wetland vegetation, soils and their associated microbial assemblages to assist in treating wastewater [20]. This technique is basically divided into two major group based on water flow regime: surface flow and sub-surface flow. Commonly only vertical and horizontal sub-surface flow are well studied. According to Lavrova, [21] vertical wetlands can remove 95.60%; Ammari [22] also found a value approximatively equal with 94%. For the removal of BOD the percentage was greater with 97% in two studies made by Lavrova, [21] and Ammari, [22]; also the average removal for Tot-N and Tot-P was 86% and 44% respectively and the average removal of TSS was 76.50%.

Moving Bed Bioreactor: The Moving bed bioreactor (MBR) is commonly used for treating wastewater and showed over the year's great results and percentage removal for most of the pollutants. Therefore, using this technique to treat greywater - source less polluted then waste water - will obviously give us great results. Based on a case study done in Morocco to treat greywater in a sports club, results showed a 98% percentage removal of turbidity, 85% of COD, 94% of BOD, 19% for Tot-N and 99% for faecal coliforms [23]. Also a case study done in Belgium showed similar results with 98%, 93.5%, 97%, 58%, 79.5% for turbidity, COD, BOD, Tot-N and Tot-P respectively [24]. Although the MBR offer great results but this technique is costly.

Cases Studies: Projects from all over the world saw the benefits of conserving and reusing this water source. In the city of Los Angles a cost-benefit analysis was conducted and found that greywater reduces 38% of potable water for multifamily homes [25]. In Canada a thesis was made to prove again that reusing greywater is the solution for minimizing water consumption, where they proved that reusing greywater reduced the consumption from 9-20% of total household use [26]. A case study done in India saved 750 to 1000 liters water per day in residential schools [27]. Many other studies proved that greywater can be the answer to water crisis and the increased water bill.

CONCLUSION

From all over the world studies and researches are trying to improve greywater treatments techniques to be more efficient and cheap. Comparing these several techniques: biosand, slanted soil, rapid sand filtration, activated carbon media, biochar media, constructed wetlands and moving bed bioreactor; biochar media with the slanted soil treatment had the best results with 96.02% and 90.30% for COD, 97% and 85.75% for BOD, 94.47% and 78.37% for Tot-N and 87.32% and 85.10% for Tot-P respectively. Because slanted soil consists of several chambers there is a possibility to combine different techniques and media's with one.

Perspectives: Mosques are one of the largest consumers of water, this Muslim's praying center play a major role in the urban water use in some important cities because Muslim must make ritual ablutions before doing his five times daily prayer, however, each individual is consuming an average of one liter of water each pray, moreover, the religious texts forbid believers to lose extra water considering it as a very precious resource. The peak of consumption is before Friday noon Prayer time, because almost obligatory to all Muslims go to mosques, which put the question of water availability problems in many Muslims countries especially in Fridays.

Recently, most mosques ablution water (greywater) is managed by mixing it with the wastewater from toilets and washing water (blackwater) moreover, some countries dispose their mosques waste water into the centralized sewage treatment plants. And since the ablution water is not very polluted and does not contain pathogens like bacteria, or chemicals like detergents, that makes it considered only partially polluted with limited quantities of inorganic materials generated by the washing of hands, face, legs and hairs from dust, sand and others.

The majority of Muslim countries are suffering from lack of water resources [28], many of them are using desalination of sea water techniques for their daily needs. Considering the reuse of Ablution water in toilets or irrigation of green areas of the mosques can be very promising solution specially by using a very simple Ablution Water Treatment Unit (AWTU) a system specially designed for ablution water (decantation, filtration) that is collected and stored in a reservoir. By treating with UV rays and or disinfecting with chlorine, the resulted treated water could be reused in ablution again.

This new ablution water reuse policy could be generalized in all Muslim countries, especially while designing the architectural drawing plans of newly established or restored mosques considering collection tanks, treatment and reuse of ablution water. A new AWTU can be easily introduced in big existing mosques because the amounts of ablution water are huge and can be reused without costly efforts for gardening or sanitation. Moreover, the installation of the AWTU in the mosque can improve the sustainability of sanitation systems and improve the water management system for the future use by reducing the generated water going to the sewage and thus saving money of the sewage treatment plant expenses.

We aim to define the feasibility conditions of an Ablution Water Treatment Unit and realize a prototype in Lebanon & France.

REFERENCES

1. UNDP, 2013. Water Governance in the Arab Region: Managing Scarcity and Securing the future. UNDP, Regional Bureau for Arab States, Beirut.

2. WHO, 2016. Results of Round I of the WHO International Scheme to Evaluate Household Water Treatment Technologies, Geneva.
3. Okun, D.A., 1997. Distributing reclaimed water through dual systems. American Water Works Association Journal, 89: 11, 52,
4. Duke, W. *et al*., 2006. Comparative Analysis of the Filtron and Biosand Water Filters. Victoria, British Columbia: University of Victoria, Restoration of Natural Systems Program.
5. Zaidun, N.A., 2011. The effect of sand filter characteristics on removal efficiency of organic matter from grey water. Al-Qadisiya Journal for Engineering Sciences, 4(2): 143-155.
6. Lakshmi, V. *et al*., 2012. Biosand Filter for Removal of Chemical Contaminants from Water, Journal of Advanced Laboratory Research in Biology, Vol. III, Issue II.,103-108
7. Itayama, T. *et al*., 2006. "On site experiments of the slanted soil treatment systems for domestic gray water. Water Science & Technology, 53(9): 193-201.
8. Kondo, T. *et al*., 2011. Decentralized domestic gray water treatment by using slanted soil chamber system. Sustainable Environment Research, 21(2): 81-87.
9. Ushijima K. *et al*., 2013. "Greywater treatment by slanted soil system. Ecological Engineering, 50: 62-68.
10. Yousaf, S. *et al*., 2013. Canal water treatment with rapid sand filtration. Soil & Environment, 32(2): 103-107.
11. Van Haute, S. *et al*., 2012. Use of biopolymers and rapid sand filtration as physicochemical reconditioning technique for vegetable washing processes. FoodMicro Abstracts, 332.
12. Bishaw, D. and F. Kebede, 1999. Evaluation of the efficiency of rapid sand filtration. 25th WEDC Conf. 25: 280-281, Adis Ababa.
13. Gazala S., 2013. Treatability Study of Waste Water Using Activated Carbon, Sand Filter and Dual Media Filter. National Conference on Biodiversity: Status and Challenges in Conservation - 'FAVEO', 210-213.
14. Berger, Ch., 2012. Biochar and activated carbon filters for greywater treatment. Master thesis, Swedish University of Agricultural Science, Uppsala.
15. Pacific Northwest, Pollution Prevention Resource Center. 2014. Emerging Best Management Practices in Stormwater: Biochar as Filtration Media. PPRC, Seattle.
16. Lobo, F.L. *et al*., 2016. Low-energy hydraulic fracturing wastewater treatment via AC powered electrocoagulation with biochar. Journal of Hazardous Materials, 309: 180-184.
17. Mohanty, S. and A. Boehm, 2014. Escherichia coli removal in biochar-augmented biofilter: Effect of infiltration rate, initial bacterial concentration, biochar particle size and presence of compost. Environmental Science & Technology, 48(19): 11535-11542.
18. Huggins, T.M. *et al*. 2016. Biochar Based Microbial Fuel Cell for Enhanced Wastewater Treatment and Nutrient Recovery. Sustainability 8-169; doi: 10.3390/su8020169.
19. Dalahmeh, S., 2013. Bark and charcoal filters for greywater treatment. Uppsala, Sveriges lantbruksuniv, Acta Universitatis agriculturae Sueciae, 1652-6880;51
20. Vymazal, J. and L. Kröpfelová, 2008. Horizontal Flow Constructed Wetlands. In Wastewater Treatment in Constructed Wetlands with Horizontal Sub-Surface Flow, 203-222, Springer.
21. Lavrova, S. and B. Koumanova, 2013. Nutrients and organic matter removal in a vertical-flow constructed wetland. In Applied Bioremediation - Active and Passive Approaches, Yogesh Patil (Ed.), InTech, DOI: 10.5772/56245.
22. Ammari, T.G. *et al*., 2014. An evaluation of the re-circulated vertical flow bioreactor to recycle rural greywater for irrigation under arid Mediterranean bioclimate. Ecological Engineering, 70: 16-24.
23. Merz, C., *et al*., 2007. Membrane bioreactor technology for the treatment of greywater from a sports and leisure club. Desalination, 215:1-3, 37-43.
24. Melin, T. *et al*., 2006. Membrane bioreactor technology for wastewater treatment and reuse. Desalination, 187:1-3, 271-282.
25. Zita Y. *et al*., 2015. Cost-Benefit Analysis of Onsite Residential Greywater Recycling – A Case Study: the City of Los Angeles. American Water Works Association Journal, E436-E444, 107-9.
26. De Luca, M., 2012. Appropriate technology and adoption of water conservation practices: Case study of greywater reuse in Guelph. Thesis University of Guelph, Canada.
27. Lambe, J.S. and R.S. Chougule, 2009. Greywater-Treatment and Reuse. Journal of Mechanical and Civil Engineering, pp: 20-26.
28. Halwani, J., 2008. Assessment of the water situation in Lebanon. The 3rd International Conference on Water Resources and Arid Environments, ICWRAE 3, King Saud University, Riyadh, Saudi Arabia.